Influence of the Digital Technologies to the Process of Learning

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Abstract: - The present paper studies the influence of the digital technologies to the process of learning. A common principle of all the traditional learning theories, which developed in a time when learning was not taking place through technology, is that learning occurs inside a person. In today's digital environment, however, we frequently need to act by drawing information which is stored within a database or an organization and is manipulated by technology. The traditional learning theories do not address this kind of learning, defined as actionable knowledge and occurring outside of people. The need to bridge this gap led to the development of connectivism, a new theory for understanding learning in our digital era. The paper outlines the headlines of connectivism, which is based on an integration of principles related to chaos, networks, and self-organization theories, and exposes briefly the reported criticisms for it and the recently developed teaching approaches related to it. A framework is also presented, due to Siemens, for organizing and comparing the primary traditional learning theories with connectivism. Our final conclusion is that none of the existing theories can stand alone as a complete theory for learning. The combination of them, however, seems to provide an adequate framework for understanding the process of learning.

Key-Words: traditional learning theories, teaching methods, artificial learning, digital technologies, connectivism.

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1 Introduction

Learning, a universal process that all individuals experience, is a fundamental component of human cognition. It combines cognitive, emotional and environmental influences for acquiring or enhancing one's knowledge or skills.

Curiosity about how humans learn dates back to the ancient Greek philosophers Socrates, Plato and Aristotle, who explored whether knowledge and truth mostly come from intellectual reasoning, i.e. they could be found within oneself (*rationalism*) or through external observation (*empiricism*). Thousands of years later, during the 17th and 18th century, the same question was the reason for a historical confrontation of two academic schools of European philosophy: The rationalists Descartes, Spinoza, Leibniz, versus the U.K. empirists Bacon, Locke, Hume.

By the 19th century, psychologists began to answer this question with systematic scientific studies. Volumes of research have been written about learning and many theories have been developed for the description of its mechanisms. The goal was to understand objectively how people learn and then develop teaching approaches accordingly.

The third Industrial Revolution (IR), however, which started in the 1940s and is widely referred as the *era of automation* [1], has transformed, with the help of computers and other "clever" machines of *Artificial Intelligence (AI)*, the human society to the digital world of our days, where technology is present in almost every aspect of our lives. Further, a fourth IR started in the beginning of the 21st century [2, 3], characterized, among others, with an advanced *Internet of Things (IoT)*, which will provide energy, goods and services at the right time and at any place. There is no doubt, therefore, that our students should take full advantage of the potential that the new digital technologies can bring for improving their learning skills.

The present work discusses the influence of the new technologies to the process of learning resulted to *connectivism*, a new learning theory for the contemporary digital human society. The rest of the paper is formulated as follows: In section 2 the

traditional learning theories and the corresponding teaching methods developed during the last two centuries are briefly exposed. In section 3 the extensive use of computers and methods of AI in Education during the last years as well as the benefits and limitations of the artificial with respect the traditional teaching and learning methods are summarized. The headlines of connectivism, the criticisms about it and the recently developed teaching approaches related to it are exposed in section 4. In section 5 a framework is presented, due to Siemens, for organizing and comparing the primary traditional learning theories with connectivism. The article closes with section 6 containing our final conclusion and some hints for future research.

2 Traditional Learning Theories and Teaching Methods

During the 20th century, the debate among the learning specialists centred on whether people learn by responding to external stimuli (*behaviorism*) or by using their brains to construct knowledge from external data (*cognitivism*).

Behaviorism, a theory established by the American psychologist John B. Watson (1878–1958), considers learning as the acquisition of new behavior based on environmental conditions and discounts any independent activities of the mind asserting that we do not know what occurs inside the learner (a "black box" activity) [4].

Cognitivism, which replaced behaviorism during the 1960′s as the dominant theory for the process of learning, argues that knowledge can be seen as a process of symbolic mental constructions and that learning is defined as change in individual's cognitive structures [5]. More explicitly, the learning process involves representation of the stimulus input, i.e., use of the contents of one's memory to find the suitable input information, interpretation of the input data to produce the new knowledge, generalization of this knowledge to a variety of situations and categorization of it in the already existing learner's cognitive schemata. In this way the individual becomes able to retrieve, when necessary, the new information from his/her proper cognitive schema and to use it for solving related problems. Changes in the learner's behavior are in fact observed, but only as an indication of what is occurring in his/her mind. In other words, cognitive theories look beyond behavior to explain the brain-based process of learning.

Constructivism, a philosophical framework based on Piaget's theory for learning and formally introduced by von Clasersfeld during the 1970s, suggests that knowledge is not passively received from the environment, but is actively constructed by the learner through a process of adaptation based on and constantly modified by the learner's experience of the world [6]. This framework is usually referred as *cognitive constructivism.*

The synthesis of the ideas of constructivism with Vygosky's social development theory [7] created the issue of *social constructivism* [8]. According to Vygosky, learning takes place within some socio-cultural setting. Shared meanings are formed through negotiation in the learning environment, leading to the development of common knowledge. The *Communities of Practice (CoPs)*, for instance, are groups of people, experts or practitioners in a particular field, with a concern for something they do and they learn how to do it better as they interact regularly, having therefore the opportunity to develop personally and professionally [9]. The basic difference between cognitive and social constructivism is that the former argues that thinking precedes language, whereas the latter supports the exactly inverse approach.

In addition to the primary learning theories, i.e. behaviorism, cognitivism and constructivism, several other options about the nature of learning have also appeared [10]. *Humanism*, for example, focuses on creating an environment leading to self-actualization, where learners are free to determine their own goals while the teacher assists in meeting those goals. The *experiential* theory suggests to combine both learning about something and experiencing it, so that learners be able to apply the new knowledge to real-world situations. Also, the *transformative* theory, which is particularly relevant to adult learners, considers that the new information can change our world views when paired with critical reflection, etc.

The role of teaching is to promote the learning of the corresponding subject. Some decades ago, the dominant teaching method used to be the *explicit instruction (EI)*, which is mainly based on principles of cognitivism. The teacher is in the "center" of this method and tries with clear statements and explanations of the teaching context and by supported practice to transfer the new knowledge to students in the best possible way [11]. The main criticism against EI is that it may prevent conceptual understanding and critical analysis [12]. Many educators, therefore, adopting ideas of constructivism, enriched the EI with a series of challenging questions so that to keep an active

discourse with students, as a means to promote critical thinking [13].

Constructivism and the socio-cultural theories for learning have become, however, very popular during the last decades as a basis for teaching, especially among teachers of the elementary and secondary education. New teaching approaches have been introduced, like the problem-based learning, the inquiry-based learning through creative exploration, the formation of virtual CoPs among students and teachers, etc.

A typical teaching method developed across these lines is the *"5 E's" instructional treatment* [14]. The acronym "5 E's" is due to the five successive phases of that treatment including engagement, exploration, explanation, elaboration and evaluation. The "5E's" method promotes the fruitful interaction among students and teachers and facilitates the production of the new knowledge on the basis of prior knowledge and experiences.

3 Computers and Artificial Intelligence in Education

In this section we discuss briefly the extensive use of computers and methods of AI in Education during the last years, as well as the benefits and limitations of the artificial with respect the traditional teaching and learning methods.

Computers provide through the Internet a wealth of information to teachers and learners, while suitably designed by the experts software packages, usually referred as *Smart Learning Systems (SLS's)***,** give to the instructor the opportunity to apply innovative teaching and learning methods in the class, like the *APOS/ACE* instruction, the *flipped learning***,** etc., that increase the student imagination and problem solving skills [1, 15-22].

The *ontologies* in computer science are knowledge-based intelligent systems designed to share knowledge among computers or among computers and people. Apart from helping the instructor in the search of learning materials and pedagogical resources in the internet, ontologies are also useful for the evaluation of the students' learning performance and for recommendations and grouping of them based on their learning behavior and skills [23-24].

An effort started during the 1980's to re-create the individual tutoring in a computer (adaptive learning systems). AI focuses in general on developing personalized curricula based on each student's specific needs. A grand experiment is in progress in China that could change the way that people learn. Squirrel and Alo7 are two of the first China's companies to pursue the concept of an AI individual tutor [25].

E-learning gives to the learner 365 days per year access to the learning subject in contrast to the traditional learning, which is scheduled as a one-time class and requires the learner's physical presence. Another advantage of e- learning is that it can be used at the same time by a large population spread throughout the world. The e-learning material, once developed as a course, could be easily modified in future for similar uses. Through e-learning students can learn in their own speed what is important for them by skipping unnecessary information. In addition, e-learning is obviously much cheaper than the traditional one, which involves many extra costs (travel, boarding, books, etc.) [26]. In concluding, e-learning appears today as a promising alternative to traditional classroom instruction, especially in cases of remote lifelong learning and training, while it can also be used as a complement of the classroom learning.

When engaged in the *Case-Based Reasoning (CBR)* approach with many past cases available, students become able to recognize more alternatives and to benefit from the failures of the others**.** Cases indexed by experts will reveal to students suitable ways of looking at a problem, a thing that they may not have the expertise to do without the help of a CBR system. The CBR methodology is useful in particular for situations where there is much to remember, because when reasoning analogically one tends to focus only on the few possible analogous past cases [27].

A *social robot* is an AI machine that has been designed to interact with humans and other robots. Social robots have been already used for entire job functions at home by understanding speech and facial expressions, in customer service, in education, etc. Two important examples for education are the robot Tico that has been designed to improve children's motivation in the classroom and the robot Bandit that has been developed to teach social behavior to autistic children [28, 29].

The impressive advances of AI in the field of Education outlined above have made a number of specialists on the subject to be certain that in future computers and the other "clever" machines of AI will replace teachers in educating students. However, although literature experiments have demonstrated that in certain cases *artificial learning* (i.e. learning acquired by using methods and techniques of AI) can be at least as effective as the conventional classroom learning, we are not in a

position to claim that it can replace the traditional classroom instruction in general [26].

In fact, in contrast to the above-mentioned advantages, there are also certain limitations of the artificial with respect to the traditional learning. One of them is that in the distance learning the queries of a student cannot be solved instantly, as the physical presence of the teacher in the classroom guarantees. Also, students in the classroom are pushed through the course to learn, whereas not every student finds e-learning suitable for his or her style. For example, some students feel bored in front of a computer. Therefore, although today thousands of online courses are offered by universities all around the world, many of them leading to degree or certificate awards, several uncertain issues and technical problems have to be further investigated concerning the effectiveness and status of artificial learning.

4 Connectivism: A New Learning Theory

The traditional learning theories outlined in section 2 were developed in a time when learning was not taking place through technology. A common principle of these theories is that learning occurs inside a person. In today's digital environment, however, we frequently need to act by drawing information which is stored within a database or an organization and is manipulated by technology. The traditional learning theories do not address this kind of learning, defined as *actionable knowledge* and occurring outside of people.

4.1 The Headlines of Connectivism

The need to bridge this gap led to the development of the idea of connectivism, which appears as a new theoretical framework to understand learning in the digital age. Connectivism was first introduced in 2004 by George Siemens on a blog post which was published as an article in 2005 [30] and it was expanded by a publication of Stephen Downes' [31]. Both works received significant attention and an extended discourse has followed since then on the appropriateness of connectivism as a learning theory and its technological implications. In 2008, Siemens and Downes delivered an online course called "Connectivism and Connective Knowledge" [32]. It covered connectivism as content while attempting to implement some of their ideas. The course was free to anyone who wished to participate, and over 2000 people worldwide enrolled. This reveals the interest of people for the new theory for learning in the digital age. Following the central presentations, the attenders could participate with their choice of tools to express their own views and remarks. The model of this course, which was repeated in 2009 and in 2011, was successfully characterized by D. Cormier and B. Alexander by the term "Massive Open Online Course" (MOOC).

Connectivism presents a model of learning that acknowledges the current shifts in society where learning is no longer an internal activity of the individual. At its core, is a form of experiential learning which prioritizes actions and experience over the idea that knowledge is propositional. Its central idea is that our ability to learn what we need for tomorrow is more important than what we know today. Consequently, when knowledge is needed, but not known, the ability to plug into sources to meet the requirements becomes a necessary skill. Learning is focused on connecting specialized information sets, and the connections that enable us to extend our knowledge are more important than our current state of knowing. The theory of connectivism is based on an integration of principles referred to *networks*, to the science of *chaos* and the *self-organization* theory.

A network can be defined as a system of connections between nodes, which is based on the principle that its nodes can be connected to create an integrated whole. Node is understood to be anything that can be connected to another node, such as an organization, a database, images, feelings, etc. Connectivism sees knowledge as a network and learning as a process of creating new connections and expanding the network's complexity.

Chaos recognizes the connection of everything to everything. It is well known, for example, the half-jokingly remark that a butterfly stirring the air today in Peking could transform storm systems next month in New York [33, p.8]. In contrast to constructivism, which states that learners attempt to foster understanding by meaning-making tasks, chaos states that the meaning exists and the learner's challenge is to recognize the patterns which appear to be hidden.

Self-organization is defined as the spontaneous formation of well-organized structures, patterns, or behaviors, from random initial conditions [34, p.3]. Learning as a self-organizing process requires that the learning system (personal or organizational) can change its structure in order to be able to classify its own interaction with an environment.

4.2 Criticisms

The idea of connectivism as a new theory for learning has drawn various criticisms. The most important of them are the following:

Verhagen [35] speaks for the ineffectiveness of a theory based on "unsubstantiated philosophizing" and considers connectivism as a rather pedagogical view.

Kerr [36] claims that although technology affects learning environments, existing learning theories are sufficient.

Kop and Hill [37] conclude that while it does not seem that connectivism is a separate learning theory, it "continues to play an important role in the development and emergence of new pedagogies, where control is shifting from the tutor to an increasingly more autonomous learner".

Ally [38] recognizes that the world has changed and becomes more networked, so learning theories developed prior to these global changes are less relevant. However, he argues that what is needed is not a new stand-alone theory for the digital age, but a model that integrates the different theories to guide the design of online learning materials.

Chatti [39] notes that connectivism misses some concepts which are crucial for learning, such as reflection, learning from failures, error detection and correction, and inquiry.

Al Dahdouh [40] examined the relation between connectivism and *Artificial Neural Network (ANN)* and the results, unexpectedly, revealed that ANN researchers use constructivism principles to teach ANN with labeled training data, whereas connectivism principles are used to teach ANN only when the knowledge is unknown.

4.3 New Teaching Approaches

As the popularity of using technological tools grows, the autonomy of learners and their control over access to information is continuously increasing. Several educators developed models of teacher and learner roles and interaction for our digital era.

Seely Brown [41], describing learning as an "enculturation practice", compares the class with an atelier and presents the teacher as a master artist who observes the student activities and draws attention to innovative approaches.

In Fisher's [42] model the teacher is compared with a network administrator whose main role is to assist learners in forming connections and creating learning networks.

Bonk [43] presents teacher as a concierge directing students to resources or learning opportunities that they may not be aware. The concierge provides a form of "soft" guidance, either incorporating traditional lectures or permitting students to explore on their own.

Siemens [44] compares teacher with a curator, who instead of dispensing knowledge, creates spaces in which knowledge can be explored, constructed and connected. He also notes that instructional designers, due to the developing complexity of tools and availability of open education resources, play an educational role of directing educators to tools and resources

5 Organization of the Learning Theories

Ertmer and Newby raised five questions on the purpose of distinguishing the learning theories [45]. Siemens [44], by answering these questions for each theory provided a framework for organizing and comparing the three primary traditional learning theories outlined in section 2 (behaviorism, cognitivism, constructivism) together with connectivism. Ertmer's and Newby's questions and the Siemens' answers for the four theories in the series that they have been previously mentioned are the following:

1. *How does learning occur?*
- Through observable behavior (what occurs inside the learner is a "black box activity")
- Structured, computational, through mind activities
- Social, meaning created by each learner (personal) as a result of social influences.
- Could be outside the learner distributed within a network, social, technologically enhanced, recognizing and interpreting patterns

2. *What factors influence learning?*
- Nature of reward, punishment, stimuli
- Existing schema, previous experiences
- Engagement, participation, social, cultural
- Diversity of network, strength of ties, digital technologies.

3. *What is the role of memory?*
- The hardwiring of repeated experiences, where reward and punishment are most influential
- Encoding, storage, retrieval
- Prior knowledge remixed to current context
- Adaptive patterns, representative of current state, existing in networks

4. *How does transfer occur?*
- Stimulus, response
- Duplicating knowledge constructs of the learner
- Socialization, constructing the new with the help of the previous knowledge
- Connecting to (adding) nodes

5. *What types of learning are best explained by this theory?*

- Task-based learning
- Reasoning, clear objectives, problem solving
- Social, vague (ill defined)
- Complex learning, rapid changing core, diverse knowledge sources

This framework enables the user to obtain his (her) own conclusions about the philosophy, the advantages and disadvantages of each of the examined learning theories.

6 Conclusion

The continuously increasing use of the new technologies in Education has changed significantly the landscape around learning, which nowadays can take place outside the individual in the form of actionable knowledge.

From the discussion performed in this paper, our conclusion is that *none* of the existing theories can stand alone as a complete theory for learning. In fact, behaviorism attempts to determine and understand learning with respect to its outer indications on the individual's behavior, cognitivism focuses on the study of the internal mechanisms of the human mind for acquiring learning and constructivism turns the attention to the suitable ways for conquering learning. All these theories do not address the learning taking place outside people in our digital era and connectivism attempts to bridge this gap. Our belief, however, is that the combination of all these theories provides an adequate framework to study and understand the process of learning. In particular, and despites the various criticisms that have been drawn, connectivism seems to stand satisfactorily as a *complement* of the traditional learning theories for the digital era. At any case, further research is needed for the correlations and ties of connectivism with the traditional learning theories, as well as for the new roles that teachers and learners are expected to play in our digital era.

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